# 2024 Chesapeake Bay Dead Zone Report
# November 2024

## Hypoxia Background

The "dead zone" of the Chesapeake Bay (Bay) refers to a volume of deep water that is characterized by oxygen concentrations less than 2 milligrams per liter (mg/L), which is too low for aquatic organisms such as fish and blue crabs to thrive. The Bay experiences such hypoxic conditions every year, with the severity varying from year to year, depending on nutrient and freshwater inputs, wind, and temperature. Multiple metrics are used to relate the severity of hypoxia between different years:

- ***Daily Maximum Hypoxic Volume*** (cubic kilometers [$km^3$]): The greatest volume of Chesapeake Bay water experiencing hypoxic conditions on any day of the year[1]
- ***Duration of Hypoxia*** (days): The number of days in a given year between the first and last day of hypoxic volume exceeding 2 $km^3$ in volume
- ***Total Annual Hypoxic Volume*** ($km^3$ days): The total amount of hypoxia in Chesapeake Bay for a given year, calculated by summing the hypoxic volume on each day

## 2024 Chesapeake Bay Hypoxia Score

The Virginia Institute of Marine Science/Batten School of Coastal and Marine Sciences[2] and Anchor QEA operate a real-time three-dimensional hypoxia forecast computer model that predicts daily oxygen concentrations in the water throughout the Bay (www.vims.edu/cbefs). The metrics listed above were estimated for 2024 from this forecast model; for reference, the same metrics have also been generated for the historical years of 1985 through 2023.[3]

**In 2024:**

- **Daily maximum hypoxic volume was greater than the majority of historical years**
- **Duration of hypoxia was less than the majority of historical years**
- **Total annual hypoxic volume was greater than the majority of historical years**

Hypoxia in summer 2024 began in early May (**Figure 1**). Hypoxia increased throughout May and peaked in the first half of June, following a period of relatively calm winds. Elevated winds in the second half of June likely resulted in a decrease in hypoxia from the early-June peak. The relatively large amount of hypoxia in June was early in the summer compared to average historical conditions, which show hypoxia generally peaking in July or even early August. Hypoxia decreased following the passage of the remnants of Hurricane Debby on August 8, 2024, but did not end for the year; a relatively low amount of hypoxia persisted through September into early October, when cooling temperatures contributed to hypoxia ending for the year. Overall, even though the duration of hypoxia was less than the long-term (39-year) average, the total annual amount of hypoxia was somewhat higher than the long-term average (**Table 1**).

The information presented here is in general agreement with the following: 1) high-resolution (10-minute) continuous measurements collected from the water surface to near the bottom that show strong tidally-driven bottom oxygen variation; and 2) water quality monitoring measurements from biweekly cruises that show hypoxia starting in April to May and increasing into early June and a large reduction in hypoxia immediately following the passage of the remnants of Hurricane Debby. These model-based estimates of hypoxia also agree with the Chesapeake Bay Program's seasonal forecast produced earlier this year, which suggested that hypoxia in 2024 would be above the long-term average.

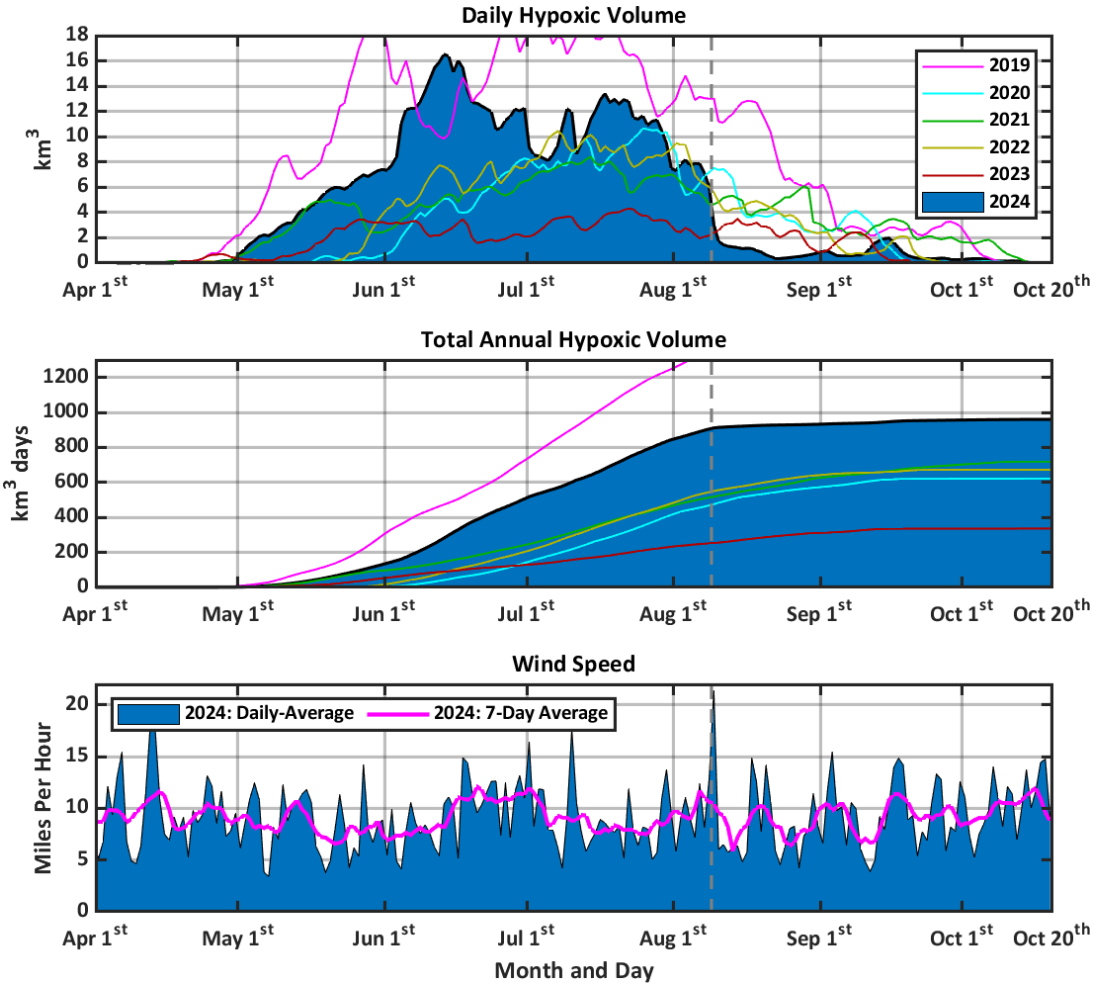
[1] 1 $km^3$ equals about 400,000 Olympic-sized swimming pools of water.
[2] Contact Marjorie Friedrichs (marjy@vims.edu) for more information.
[3] These estimates are based on computer models that continue to be improved; therefore, past estimates may be updated as improvements are made.

**Table 1. Severity of hypoxia estimated using the forecast model. Note that 2024 values were within the historically normal and recent past (2019-to-2023) ranges for the total annual hypoxic volume and average summer hypoxic volume. For more detailed information, see www.vims.edu/cbefs.**

| Year | Duration of Hypoxia (days) | Total Annual Hypoxic Volume (summed over each day; $km^3$ days) | Daily Maximum Hypoxic Volume ($km^3$) |
|---|---|---|---|
| Historical* | 96 to 146 | 418 to 1,075 | 6.2 to 13.4 |
| 2019 | 154 | 1,688 | 20.2 (25%) |
| 2020 | 101 | 623 | 10.7 (13%) |
| 2021 | 143 | 720 | 8.4 (10%) |
| 2022 | 114 | 673 | 10.4 (13%) |
| 2023 | 113 | 336 | 4.3 (5%) |
| 2024 | 96 | 961 | 16.5 (20%) |

*Historical values are based on long-term model simulations of 1985 to 2023. Values within the ranges listed can be considered relatively normal based on the 1985-to-2023 values. The range is the long-term median (121 days, 747 $km^3$ days, 9.8 $km^3$, and 5.5 $km^3$) plus and minus one standard deviation. The median is the value where half the historical yearly values are lower and half are higher. The standard deviation represents year-to-year variability. Percentages (%) represent the percent of the volume of the Chesapeake Bay that was hypoxic.[4]

**Figure 1. Hypoxic volumes for 2019 to 2024 and wind speed over Chesapeake Bay for 2024. The remnants of Hurricane Debby passed by Chesapeake Bay in early August (vertical dashed line).**




[4] The Chesapeake Bay water volume was based on the volume in the forecast model.